

# A Multivariate Analysis of the Interplay between Energy Resources, Economic Growth, and Financial Stability. Evidence from Azerbaijan

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**Abstract.** *The aim of this research is to conduct an objective and predictive evaluation of Azerbaijan's economic growth from 1997 to 2022. Since Azerbaijan is a significant exporter and producer of energy resources, its economic growth is substantially influenced by the remarkable advancements in oil and gas extraction and production since the early 2000s. Methodologically, we have designed several models to ascertain the influence and impact of the following explanatory factors-oil reserves, natural gas reserves, net trade, current account balance, inflation rate, unemployment rate, interest rate and carbon dioxide emissions - on the economic growth rate. The study utilised a combination of uni- and multi-factorial linear regression techniques, with accuracy and robustness testing conducted on all eight models. Research hypotheses were tested and a predictive analysis was implemented and evaluated over the studied period. Our findings demonstrate that the growth of Azerbaijan's economy is positively impacted by the dynamics and development of energy product trade, particularly in oil. As a result, GDP increased by an average of 2.50%. It is also confirmed that inflation and unemployment have a negative impact which unavoidably leads to instability and an economic downturn. In contrast, the robustness indicators (namely, RMSE, MAE and MAPE) could assess the predictive analysis of economic growth. The validated, low values further endorse the credibility of the eight models in accurately forecasting the economic growth rate throughout the studied period. The study disproves the existence of a positive correlation between GDP and the quantity of carbon dioxide emissions. However, it has been demonstrated that Azerbaijan is taking significant measures to achieve its environmental objectives. These measures include the implementation of taxation, a reduction in CO<sub>2</sub> emissions by up to 55% by 2030, and a shift towards renewable energy sources. Our research aims to enhance the utilisation of renewable energy resources, increase the efficiency of the domestic energy infrastructure and implement measures to moderate high levels of unemployment and inflation, thus ensuring sustained economic growth in Azerbaijan.*

**Keywords:** Economic growth, Energy resources, Azerbaijan, Linear multivariate regression, Energy Security, Financial Instability.

## Introduction

The development of the statistical and the econometric models to study and assess the degree of economic growth and development is relevant and increasingly addressed in scientific studies.

From this perspective, the present study proposes to carry out an analysis to estimate and predict the economic growth in Azerbaijan for the period 1997-2022.

The motivation for this country in the Caspian region is suggested by its endowment and richness in domestic energy resources (in particular, reserves of fossil fuels: natural gas and oil), as well as the beneficial and positive impact of these energy resources in terms of prosperity and economic growth. In addition, Azerbaijan is a major producer and exporter of energy resources at the global level, and the dynamics and development of trade in these products is a significant driver of economic growth. The country's energy profile shows that its efforts have long been directed towards the search for new oil and gas fields and production areas, which has led to the constant improvement and optimisation of the domestic energy sector.

Azerbaijan's economy is heavily dependent on its ability to extract and produce energy resources. As such, the energy sector has been the main driver of economic growth since the country gained independence in 1991. There are also several challenges and dependencies on the extractive industries that create negative exposure to oil price volatility. For example, gross domestic product (GDP) growth averaged 1.4% per year between 2013 and 2017, down from 5.5% between 2008 and 2012. The country's hydrocarbon sector was responsible for most of the decline, contributing around a third of GDP and accounting for over 90% of total exports (International Energy Agency, 2023; Statista, 2023a). The fall in global oil prices in 2014 and the resulting decline in oil production drove this contraction. It also led to lower remittances from Azerbaijan's hydrocarbon-rich trading partners. However, Azerbaijan's economic growth recovered quickly after being severely hit by the Covid-19 pandemic, which caused the country's economy to contract by 4.3% in 2021 (Statista, 2023b). Strong performance in manufacturing, transportation, retail trade, and information and communications technologies supported recovery, and growth also continues to rebound in services, including the hospitality sector.

Statistical data confirm that the level of economic growth (on average) is over 1.50%, oil and gas account for more than 90% of Azerbaijan's exports, with production rising sharply in the 2000s following the discovery of the Shah Deniz gas field and reaching record levels in 2010 (International Energy Agency, 2021; International Energy Agency, 2023; Caspian Center for Energy and Environment, 2020). The government and international companies have invested heavily in the energy sector, and the construction of several new power plants and the rehabilitation and upgrading of gas and electricity networks have improved reliability and security of supply.

Analysing the current situation on economic activity in Azerbaijan, according to data provided by the International Trade Administration (2023) and Statista (2023b), GDP has increased by up to 5% in the last year, and during this period, the country's non-oil GDP grew by 9.1%, while oil GDP fell by 2.7%. In 2022, Azerbaijan reported a 55.4% increase in foreign trade to \$52.7 billion. For instance, the country also reported an overall increase in total net exports, with exports up 71.6% year-on-year to \$38.1 billion and imports up 23.9% to \$14.5 billion. However, Azerbaijan continues to promote the diversification of its economy away from hydrocarbons, and is seeking to develop the green energy, agriculture, logistics, tourism and information and communication technology (ICT) sectors. Azerbaijan is also taking steps towards more sustainable energy production in the returned territories.

A particular focus is on how oil and natural gas exports have contributed to Azerbaijan's economy. In this regard, the oil export is carried out via three major and main pipelines, as follows: about 80% of the country's oil is exported through the Baku-Tbilisi-Ceyhan (BTC) pipeline, which came on stream in 2006 and has a capacity of 1.2 million barrels per day. It

transports crude oil from the ACG field and condensate from Shah Deniz from the Sangachal terminal near Baku through Georgia to the Mediterranean port of Ceyhan in Turkey, from where the oil is shipped by tanker to world markets. The second oil pipeline is the Baku-Novorossiysk pipeline runs from the Sangachal terminal on the Caspian Sea to the Novorossiysk terminal on the Black Sea in Russia. It is 1 330 km long with a capacity of 105 000 barrels per day (b/d) and has been operating since 1996; SOCAR operates the Azerbaijani section and Transneft operates the Russian section. And finally, the third oil pipeline is the Baku-Supsa pipeline, whose route parallels that of the BTC via Azerbaijan and Georgia, transports crude oil from offshore oilfields in the Caspian Sea to Supsa, Georgia, on the Black Sea where it continues to European markets via tankers. It is 833 km long with a capacity of 145000.00 b/d and has been in operation since 1999. The latest statistical data (Statista, 2023a; Statista, 2023b) shows that the volume of oil exports from Azerbaijan in the first half of 2023 reached 9 thousand metric tons, where the main importing countries included Italy, India, Israel, Spain and Turkey.

In terms of natural gas exports, the two pipelines are the South Caucasus Pipeline (SCP) that transports gas from the Shah Deniz field through Georgia to Türkiye parallel to the BTC crude oil pipeline. The SCP is 693 km long (443 km in Azerbaijan and 250 km in Georgia) and has a capacity of 7.00 bcm, and the Hajigabul-Mozdok, which transported natural gas from Russia to Azerbaijan until 2007 when an agreement between SOCAR and Gazprom allowed the pipeline's flow to be reversed, and gas exports to Russia began in 2010. The pipeline's annual capacity is 10.00 bcm, and 200 km of its total 680 km are in Azerbaijan. SOCAR and Gazprom (Russia) operate this pipeline.

Furthermore, Azerbaijan has become a new player in the European gas market after the EU replaced most of its dependence on Russia for its energy supplies. According to Azerbaijan's Ministry of Energy, the country produced 46.70 bcm of natural gas in 2022 (up from 43.80 bcm in 2021). For example, the data show natural gas exports of 22.30 bcm in 2022, up from 19.00 bcm in 2021 (a rise of 18%), of which 11.40 bcm went to the EU, compared with 8.10 bcm in 2021. In this regard, the rise in gas exports to the EU was mainly achieved owing to infrastructure operating at full capacity and stable supplies (Howey, 2023). The implications in terms of securing and optimising the transport routes of energy resources are confirmed by the creation and development of new routes and projects (i.e. The Trans Adriatic Pipeline-TAP, The Trans Anatolian Natural Gas Pipeline Project -TANAP, The South Caucasus Pipeline-SCP, The Baku-Tbilisi-Ceyhan Pipeline - BTC and the Southern Natural Gas Corridor project), as well as the attraction of foreign direct investment, which will generate a higher rate of labour productivity, increasing the labour force in these extractive sectors, thus having a positive and direct impact on the economic growth rate.

In this context, statistical data provided by BP Statistical Review of World Energy (BP, 2021) confirms that natural gas reserves are estimated at around 2.50 tcm (trillion cubic metres), while oil reserves are around 7 trillion barrels, with the discovery of ACG and Shah Deniz fields contributing significantly to the total amount of discovered and proven reserves of energy resources within Azerbaijan. However, we bear in mind that the sequence of current events, which create uncertainty and risk, is leading to a slowdown and decline in economic growth, particularly in terms of movements and fluctuations in global energy prices, rising inflation, rising unemployment and rising lending rates.

For example, Valiyev (2023) performs a predictive analysis of the interrelationship between economic growth and energy exports in Azerbaijan for 2023 and 2024. The results show that net exports will rise in 2023 on higher hydrocarbon exports and lower imports before

moderating in 2024 on cuts to hydrocarbon output and higher imports to meet improving domestic demand. Furthermore, the increased volume of oil and gas exports in the last two years (2021-2022) positively influences the economic activity, the economic growth being projected to moderate in 2023 and accelerate slightly in 2024. In this regard, the slowdown to 3.5% in 2023 will reflect a lower rate of expansion in the non-hydrocarbon economy, and it is expected to recover to 3.8% in 2024, together with oil production, following the rehabilitation of oil field infrastructure in 2022.

Meanwhile, the Caspian nation's environmental efforts are noteworthy, as it has committed to reducing its greenhouse gas (GHG) emissions by 35% by 2030 compared to the base year of 1990 in its Nationally Determined Contribution (NDC) under the Paris Agreement, which emphasises the use of alternative and renewable energy sources to achieve this goal. Renewable energy is also the most promising low-carbon solution to meet Azerbaijan's climate goals. Given that Azerbaijan is making significant progress in reducing carbon dioxide emissions and protecting the environment, this country is currently pursuing wind and solar projects with the goal of becoming an exporter of green energy to European markets. The government aims to increase the share of renewable energy in electricity production to 30% by 2030 through the phased installation of 1500 MW of renewable generation capacity. For example, key concessions to promote development of renewable energy include a 7-year VAT exemption for technical equipment and facilities, customs duties exemption, and in some cases the exemption from land and property tax and 50% of income tax.

The econometric analysis carried out in this study was based on eight models to study and evaluate the level of economic growth in a "waterfall" manner, including the following variables: GDP, oil reserves, natural gas reserves, inflation, net trade, current account balance, and unemployment and carbon dioxide emissions. From a methodological point of view, we also applied the linear regression method in different forms: univariate and multivariate and the entire analysis were carried out for the period 1997-2022. In addition, it was possible to determine the impact of these explanatory variables on the level of GDP (as a dependent variable) by testing and statistically validating the research hypotheses centred on the rate of economic growth (these are detailed in the Section 3: Research methodology). The analysis also allowed to assess and diagnose the reliability of the proposed models, as well as to predict economic growth over the time interval studied and within this Caspian country.

With regard to the structure of the article, Section 1 provides an overview of the introductory elements; the following section (Section 2) is a systematic review of the literature in this area, while Section 3 provides a description of the variables and data used, a presentation of the econometric models and analytical tools applied to economic growth in Azerbaijan, and an outline of the research hypotheses to be tested and verified. Section 4 discusses and presents the main findings and results. The study then concludes with a presentation of conclusions, implications and new future directions for research on the level of economic growth and economic development.

## Literature review

This section presents the main theoretical and empirical insights that are suggested and highlighted in the scientific literature. In this context, the literature review consists of illustrating and systematically reviewing the studies and researches that examine the interdependent

relationship between energy, economic growth and economic development for the analysed country in this study, namely Azerbaijan.

Surprisingly and pleasingly, from this point of view, we can observe a growing and intense interest on the part of researchers and academics in addressing the issue of economic growth in producing and rich countries endowed with traditional energy resources (natural gas, oil, fossil fuels), starting from their energy profile and potential, presented/evidenced by statistical data and information provided in official reports of International Energy Agency (2021) and International Energy Agency (2023). According to these reports, the domestic energy sector in Azerbaijan is a key driver of prosperity and economic growth in the medium and long term, as oil and gas accounting for about 90% of Azerbaijan's export earnings and financing around 60% of the state budget. They also provide 98% of the country's primary energy and more than 90% of its electricity. Oil and gas have been largely responsible for the remarkable rise in living standards in Azerbaijan since the late 1990s. In addition, Azerbaijan produces about four times as much energy as it consumes and has one of the highest levels of energy self-sufficiency in the world.

In recent years, it has exported almost 90% of its oil production and over 40% of its natural gas. In this context, the statistics confirm that the dominance of the oil and gas sector has made the economy more dependent on industry and construction (52.2% of GDP in 2018) than on services (34.8%). Also, the dynamics of the oil and gas sector have a significant impact on economic growth, both through industrial activity and consumer spending linked to employment and salaries. At the same time, it is suggested that energy exports are extremely beneficial to the economy in terms of growth, providing over 60% of government/public consumption, the key economic challenge is therefore to develop a diversified economy, with new and sustainable sources of growth and it is more competitive in global and regional markets (Country Partnership Strategy: Azerbaijan, 2014).

Against this background, maintaining the desired level of economic growth will be influenced by the Caspian country's ability to attract foreign direct investment and diversify its export options through the establishment and development of new pipelines and infrastructure projects. In addition, ensuring price stability through inflation targeting by a combination of factors including high oil prices, large fiscal stimulus, a stable exchange rate against the dollar, monetary expansion, imported food prices and rapid household credit growth dealing with the negative effects of unemployment and labour market challenges (one problem is the increase in unemployment among the young population and their low education and skills), which lead to a decline in productivity, are real challenges affecting the pace of economic growth for Azerbaijan (Country Partnership Strategy: Azerbaijan, 2014).

According to Valiyev (2023), the author conducts a forecast analysis of economic growth, the results of which show that the growth is expected to moderate in 2023 and accelerate slightly in 2024. The slowdown to 3.5% in 2023 will reflect less expansion in the non-hydrocarbon economy, which is expected to recover to 3.8% in 2024, together with oil production, following the rehabilitation of oilfield infrastructure in 2022. Meanwhile, gas production will continue to expand. The same study (Valiyev, 2023) also suggests that the level of lending rates remains quite high as a monetary policy measure to curb inflation, which has doubled to 14% by 2022. Azerbaijan's efforts can also be seen in the increasingly accentuated and intense impact (since 2015) of the transition to a clean energy system and the use of renewable energy sources, all of which contribute to prosperity and economic well-being.

For example, a study conducted by Muradov (2021) analyses the impact of private oil and gas projects on economic growth in Azerbaijan. The main empirical evidence captured the beneficial effects of these investment projects, which have an increasing role in reducing the level of poverty and unemployment for this country. In addition, this study has drawn attention to the possible problems that Azerbaijan may face in the medium and long term due to its high dependence on the volume of exports of these energy resources, as well as the existence of fluctuations in global oil and natural gas prices, but also corruption, which has a negative impact on economic performance and is aimed at slowing growth; it's called the resource curse theory, and the economy should diversify at a faster pace to avoid long-term stagnation (Muradov, 2021; Mukhtarov, 2020a; Mukhtarov et al., 2020b).

The methodology based on the Herfindahl-Hirschmann export diversification index and industry concentration in GDP proposed by Ahmadova et al. (2021) leads to the analysis of measuring and estimating the diversification and economic integration fence within the country of Azerbaijan from 1990 to 2019. Following the application of the multifactor regression method, the results showed a direct and strong interdependent relationship between GDP, oil price and exchange rate, which confirms the existence of an export specialised in mineral products was identified, while a possible implication of the study is the attraction of new investment projects to small and medium enterprises operating in non-oil sectors.

Similarly, the study carried out by Huseynli (2022), where after the Granger causality analysis for the period 1994-2018, it was shown that there is no long-term causality relationship between economic growth and exports of energy resources, but there is a strong significant relationship between these two variables after the statistical evaluation of the cross-correlation analysis. In addition, the author of this study (Huseynli, 2022) strongly recommends and supports the implementation of economic policies that encourage increased and diversified volumes of energy exports (especially those aimed at reducing the consumption of energy resources) in the coming period for this Caspian country under consideration.

Another direction of research on the analysis of the economic growth rate in Azerbaijan is found in the research conducted by Mamadova et al. (2019). The authors make a series of correlations in order to study the interrelations between energy, non-energy and innovative sectors at the level of GDP during 2001-2018. Empirical evidence suggests that the development of the innovative economy is one of the key priorities for Azerbaijan, and economic activity in Azerbaijan has the power to generate innovations or to finance the development of these innovations. An interesting way to assess the level of economic growth in Azerbaijan is found in the research of Humbatova et al. (2023). Using specific co-integration methods (i.e. Granger causality test, Wald test, FMOLS, DOLS multiple regression and ARDL econometric model), it was possible to determine the impact of transfers from the State Oil Fund (SOFAZ) to the state budget on GDP and economic welfare using quarterly frequency data over the period 2003-2021. In order to examine the long-term causality relationships between oil prices and diversification away from oil, the study conducted by Gurbanov et al. (2017), and from a methodological point of view, provides the ARDL model including the following variables: oil prices, government investment expenditure, non-oil exports and non-oil GDP for Azerbaijan.

Following the application of Johansen co-integration tests, the estimation of short-run and long-run coefficients for each test, as well as the implementation of diagnostic and precision tests during the period under analysis (2000-2013), the findings show that despite massive government investment spending, very little non-oil tradable output has been generated, highlighting the need for policy reform. In a similar manner, Humbatova and Hajiyeu (2019) have shown that oil is an

important and increasingly relevant determinant of economic activity in net energy producing and net energy exporting villages. Specifically, by applying multivariate analysis (i.e. VEC model, Engel-Granger tests and FMOLS-DOLS-CCR co-integration methods), the results of this study showed that energy price fluctuations directly affect economic growth. The economic growth is influenced by energy prices, financial development and renewable energy consumption. This is suggested by the application of the ARDL model in Azerbaijan in the period 1993-2015.

Other studies conducted by Chontanawat et al. (2008); Ahmadov (2021) applied co-integration methods in estimating and forecasting economic growth in oil and gas rich countries and found that the dependence of oil prices on world GDP and world industrial production, daily oil production and world oil consumption has gradually decreased. The authors of this study (Mukhtarov et al., 2020c) showed that financial development and economic growth have a positive impact on renewable energy consumption, increasing it by an average of 0.38%. It was also noticed that the positive influence of financial development on energy demand is important for the implementation of an appropriate energy policy based on alternative energy sources.

The existence of bi-directional causality relationship between economic growth and financial development has been demonstrated and conformed for the state of Azerbaijan by applying specific co-integration methodology (i.e. VEC model, Granger causality tests) in the study conducted by Mammadov and Ahmadov (2021). According to some researchers (Mukhtarov et al. 2019; Mukhtarov et al., 2022), financial development plays an important role for economic growth, while for others it can be considered unimportant.

On a similar note, the study by Mikayilov et al. (2018) examines the interdependent relationship between economic growth and the level of carbon dioxide emissions over the period 1992-2013 for Azerbaijan. Empirically, it was found that the EKC (i.e. Environmental Kuznets Curve) hypothesis is not confirmed for this country, but it was shown that the economic growth has a positive and statistically significant impact on emissions in the long term. The co-integration relationship between renewable energy consumption, real GDP per capita, exports, imports and consumption-based CO<sub>2</sub> emissions in Azerbaijan was estimated using the Engle-Granger, Park's added variables and Phillips-Ouliaris tests (Mukhtarov et al., 2023). The main findings of the study suggest that the negative impact of the consumption of renewable energy and the greater impact of imports emphasise the need to implement environmentally friendly measures in the energy sector in Azerbaijan.

Another perspective focuses on Azerbaijan's growing and intensive role in ensuring European energy security. In this context, we mention the studies conducted by Azakov (2018); Azimov (2021); Rzayev and Aliyev (2023) which present the main factors that can facilitate better energy cooperation between Azerbaijan (as an exporter) and the European Union (as an importer). Thus, the authors draw attention to the positive effects of the Southern Gas Corridor project, from which both political entities will benefit. For Azerbaijan, the intensification of energy contacts with the EU will provide an opportunity not only to obtain hard currency, but also to modernise its economy; to increase exports of energy products, as well as to optimise and rationalise the domestic energy system. In the case of the European Union, this administrative entity will be able to significantly reduce its dependence on Russian energy resources, which will have a positive impact on stability and strengthen energy security in the EU member states.

For example, the theoretical analysis presented in the study performed by Hasanov et al. (2020) shows that the EU's preference and support for the import of Azeri gas in particular, and the SGC in general, fits well with its diversification strategy, even if these imports are not the most economical for the region. Against this background, the authors (Muradzada et al., 2023)

conclude that it is an accepted fact that Azerbaijan, which occupies a key geopolitical position, uses its energy resources as an influential actor to protect and strengthen its independence. In addition, economic growth can be ensured both in terms of the role of energy resources, which is one of the most influential factors in ensuring both political and economic freedom in Azerbaijan, and in terms of attracting investment projects in the field of extraction and infrastructure, both of which have remarkable and valuable implications for the efficiency of foreign trade in oil and gas.

The main objective of this section was to present and discuss the academic studies that have focused on the study and analysis of economic growth in Azerbaijan over different time periods, using different and multiple explanatory variables and specific techniques and methods.

As a result, economic growth is strongly related and influenced by domestic energy production, global energy prices, energy consumption, financial development, amount of carbon dioxide, as well as the growing use of renewable energy sources.

## Methodology

The main objective of the present study is to estimate and forecast the level of economic growth in Azerbaijan for the period from 1997 to 2022. We considered it is useful to carry out such research in order to examine and determine the interdependencies/impacts on the level of economic growth in the case of this Caspian country, as Azerbaijan is playing an increasingly important role in maintaining energy security within the European Union, with real progress being made in the efficiency and optimisation of energy resource transport routes (e.g. the Southern Gas Corridor), the potential for the development and discovery of oil and gas reserves, as well as an increasing role in the global trade of such energy resources, and an intense focus on reducing carbon dioxide emissions in line with the EU target of reducing net greenhouse gas emissions by at least 55% by 2030).

Thus, the analysis is highlighted by building eight models for estimating and forecasting economic growth for Azerbaijan in the period 1997-2022. In this regard, the variables included for each model are GDP as the dependent variable, while oil reserves, natural gas reserves, net export, current balance of payments, inflation, unemployment and carbon dioxide emissions are explanatory and independent variables included in the economic analysis.

According to scientific studies (Chontanawat et al., 2008; Mukhtarov, 2020a; Dong et al., 2021), there is a growing concern to identify factors that ensure a robust estimation and prediction of economic growth, so that GDP remains the relevant and popular economic indicator, regardless of the way and form in which it is presented and analysed (i.e. GDP, GDP per capita, real GDP, nominal GDP, etc.). Given Azerbaijan's status as a net producer and net exporter of energy products (especially fossil fuels), economic growth may be influenced by the endowment of these energy resources and the evolution and dynamics of trade activity, and for this reason the following explanatory variables were included in our analysis: quantity of oil reserves, quantity of natural gas reserves, net export/trade balance and current account balance.

At the same time, the inflation rate, unemployment rate and lending interest rate have been included in order to check the financial and monetary stability and possible allegations that may negatively affect the economic growth rate of Azerbaijan. Another explanatory variable was the amount of carbon dioxide emissions, which was designed to examine and observe the extent to which the implementation of measures to reduce and tax pollution affects the economic growth

of the Azerbaijani state, which was discussed and debated by Abutalibov and Guliyev (2013); Maradana et al. (2017); Musayev and Aliyev (2017).

Table 1 and Figure 1 show the description of the variables, the units of measurement, the sources of data and their evolution over the period analysed.

**Table 1. Description of the variables**

| Variable                        | Definition                                                                                                                                                                                                                                                            | Measurement unit                            | Source                                                                               | Type of variable     |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|--------------------------------------------------------------------------------------|----------------------|
| <i>GDP</i>                      | GDP is gross domestic product converted to international dollars using purchasing power parity rates.                                                                                                                                                                 | Constant 2017 international dollars.        | World Bank Database                                                                  | Dependent variable   |
| <i>Crude oil reserves</i>       | Total proved reserves of oil are generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions.        | Billion barrels of petroleum liquids (BBL). | Energy Institute Statistical Review of World Energy & Our World in Data <sup>1</sup> | Independent variable |
| <i>Natural gas reserves</i>     | Total proved reserves of natural gas is generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions. | Thousand cubic meters (TCM).                | Energy Institute Statistical Review of World Energy & Our World in Data <sup>2</sup> | Independent variable |
| <i>Net trade</i>                | Net trade in goods is the difference between exports and imports of goods.                                                                                                                                                                                            | Current U.S. dollars.                       | World Bank Database                                                                  | Independent variable |
| <i>Current account balance</i>  | Current account balance is the sum of net exports of goods and services, net primary income, and net secondary income.                                                                                                                                                | Current U.S. dollars.                       | World Bank Database                                                                  | Independent variable |
| <i>Inflation</i>                | Inflation as measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole.                                                                                                                                | Annual %.                                   | World Bank Database                                                                  | Independent variable |
| <i>Lending interest rate</i>    | Lending rate is the bank rate that usually meets the short- and medium-term financing needs of the private sector.                                                                                                                                                    | Annual %.                                   | World Bank Database                                                                  | Independent variable |
| <i>Unemployment</i>             | Unemployment refers to the share of the labour force that is without work but available for and seeking employment.                                                                                                                                                   | % of total labour force.                    | World Bank Database                                                                  | Independent variable |
| <i>CO<sub>2</sub> Emissions</i> | Annual total emissions of carbon dioxide from fossil fuels and industry (excluding land-use change).                                                                                                                                                                  | Million or billion tonnes                   | Our World in Data <sup>3</sup>                                                       | Independent variable |

Note:<sup>1</sup>Data are available from: <https://www.energyinst.org/statistical-review/>; <https://ourworldindata.org/grapher/oil-proved-reserves?tab=table.2> Data are available from: <https://www.energyinst.org/statistical-review/>; <https://ourworldindata.org/grapher/natural-gas-proved-reserves?tab=table>. <sup>3</sup>Data are available from: <https://ourworldindata.org/grapher/annual-co2-emissions-per-country?tab=table>.

Source: Authors' work.

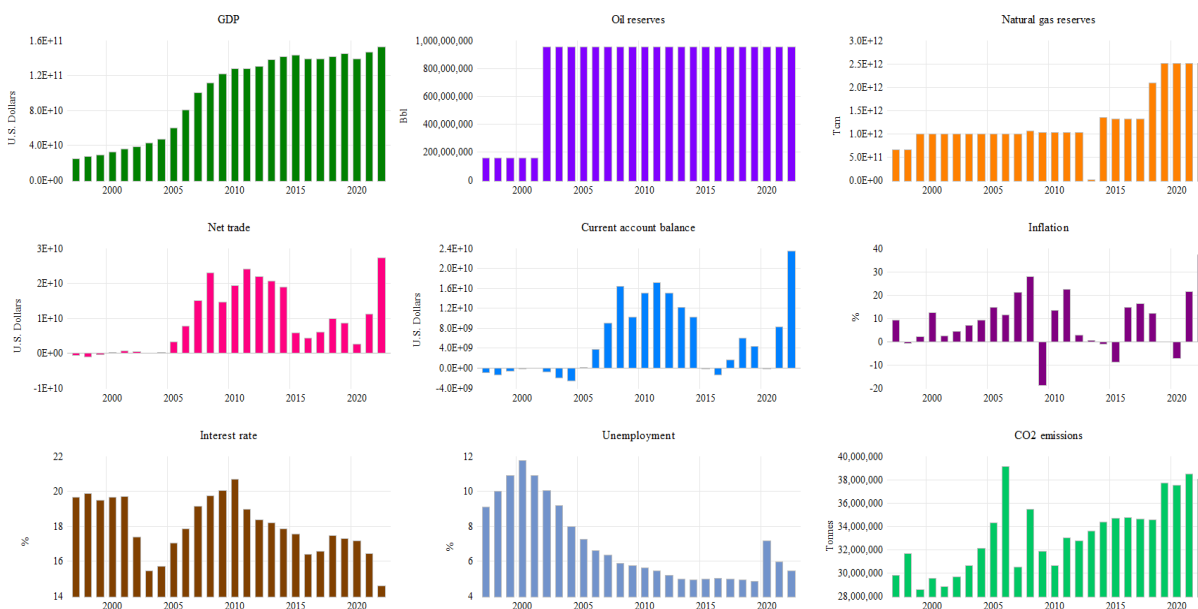


**Figure 1. Data representation**

Source: Authors' work using EViews 12.

Table 2 provides a statistical description of the variables included in the economic growth models, showing the indicators of central tendency (mean, and mean standard deviation), and the indicators describing the shape of the distribution (coefficients of Skewness and Kurtosis).

There is therefore a high degree of heterogeneity in the variables used; unemployment, the lending rate and carbon dioxide emissions are platykurtic, while oil reserves, natural gas reserves and inflation are leptokurtic. The values of the Skewness coefficient indicate that GDP is asymmetric to the left (negative values), while the rest of the variables are asymmetric to the right (positive values), confirming the statistical term 'fat tails', which refers to probability distributions with a relatively high probability of extreme outcomes and also implies a strong influence of extreme observations on the expected values. When we calculated the coefficient of variation (as a percentage ratio of the standard deviation to the mean), we found a high degree of heterogeneity in most of the time series analysed.

**Table 2. Descriptive statistics of variables (at the level)**

| Variable                        | Mean                 | Standard Deviation | Kurtosis | Skewness |
|---------------------------------|----------------------|--------------------|----------|----------|
| <i>GDP</i>                      | 98.427.373.050,38    | 48.162.268.013,44  | 1,46     | -0,45    |
| <i>Oil reserves</i>             | 801.864.123,08       | 319.632.940,06     | 3,43     | -1,56    |
| <i>Natural gas reserves</i>     | 1.260.478.139.942,31 | 636.840.391.489,06 | 3,25     | 0,88     |
| <i>Net trade</i>                | 9.370.144.115,38     | 9.201.540.584,64   | 1,83     | 0,50     |
| <i>Current account balance</i>  | 5.488.544.346,89     | 7.427.771.341,99   | 2,44     | 0,77     |
| <i>Inflation</i>                | 8,67                 | 12,13              | 3,19     | 0,09     |
| <i>Interest rate</i>            | 18,01                | 1,61               | 2,16     | -0,23    |
| <i>Unemployment</i>             | 6.97                 | 2,25               | 2,26     | 0.85     |
| <i>CO<sub>2</sub> Emissions</i> | 33.325.187,00        | 3.136.424,55       | 2,02     | 0,25     |

Source: Authors' work using EViews 12.

In addition, the variables included in each model have an annual frequency and are transformed using the natural logarithm in order to obtain consistent, appropriate and coherent results, with the exception that the variables describing net exports and the current balance of payments have been expressed in absolute value and logarithmic terms in order to include them in the regression-based analysis. The specifications and equations of these "one-way level from multi-level" models are shown in Table 3 below.

**Table 3. The presentation of the econometric models**

| Model   | Equation                                                                                                                                                                                                                        |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Model 1 | $GDP_t = \alpha + b_1 Oil\ reserves_t + \varepsilon_t$                                                                                                                                                                          |
| Model 2 | $GDP_t = \alpha + b_1 Oil\ reserves_t + b_2 Natural\ gas\ reserves_t + \varepsilon_t$                                                                                                                                           |
| Model 3 | $GDP_t = \alpha + b_1 Oil\ reserves_t + b_2 Natural\ gas\ reserves_t + b_3 Net\ trade_t + \varepsilon_t$                                                                                                                        |
| Model 4 | $GDP_t = \alpha + b_1 Oil\ reserves_t + b_2 Natural\ gas\ reserves_t + b_3 Net\ trade_t + b_4 Current\ account\ balance_t + \varepsilon_t$                                                                                      |
| Model 5 | $GDP_t = \alpha + b_1 Oil\ reserves_t + b_2 Natural\ gas\ reserves_t + b_3 Net\ trade_t + b_4 Current\ account\ balance_t + b_5 Inflation_t + \varepsilon_t$                                                                    |
| Model 6 | $GDP_t = \alpha + b_1 Oil\ reserves_t + b_2 Natural\ gas\ reserves_t + b_3 Net\ trade_t + b_4 Current\ account\ balance_t + b_5 Inflation_t + b_6 Interest\ rate_t + \varepsilon_t$                                             |
| Model 7 | $GDP_t = \alpha + b_1 Oil\ reserves_t + b_2 Natural\ gas\ reserves_t + b_3 Net\ trade_t + b_4 Current\ account\ balance_t + b_5 Inflation_t + b_6 Interest\ rate_t + b_7 Unemployment_t + \varepsilon_t$                        |
| Model 8 | $GDP_t = \alpha + b_1 Oil\ reserves_t + b_2 Natural\ gas\ reserves_t + b_3 Net\ trade_t + b_4 Current\ account\ balance_t + b_5 Inflation_t + b_6 Interest\ rate_t + b_7 Unemployment_t + b_8 CO2\ Emissions_t + \varepsilon_t$ |

Where:  $GDP_t$  is the dependent variable;  $\alpha$  is the intercept term;  $b_1 \rightarrow b_8$  are the estimated coefficients for the explanatory/independent variables,  $\varepsilon_t$  is the error term, and  $t$  is the time period from 1997 to 2022.

Source: Authors' work.

Moreover, the development of the eight econometric models is based on the determination and evaluation of the impact of the explanatory variables on the economic growth rate in Azerbaijan during the mentioned period, together with their sequential incorporation in order to validate or invalidate the following research hypotheses:

*H<sub>1</sub>: Energy resources have a positive impact on the economic growth of the Azerbaijani state;*

*H<sub>2</sub>: Trade in goods and services and its dynamics contribute to the economic growth of Azerbaijan;*

*H<sub>3</sub>: Price and financial instability have a negative impact on the economic growth rate in Azerbaijan.*

*H<sub>4</sub>: Economic growth and environmental pollution are negatively correlated.*

*H<sub>5</sub>: There is a counter-cyclical relationship between unemployment and economic growth.*

Furthermore, in order to determine the interdependencies between energy resources and economic growth in the case of Azerbaijan, we choose to apply the econometric method in the form of linear multifactor regression. In the field of economics, multifactor models have a wide range of applications, they can be used in many situations and in various forms, and are very

popular among researchers. Multivariate linear regression has two main functions: to determine the influence of several independent variables on the dependent variable, and to perform a predictive analysis of the endogenous variable after testing the validity of the model.

From this perspective, we follow the specific direction of analysis for each multifactor regression model, based on the following assumptions: the regression model is correctly specified; the independent variable has zero variance; the mean of the error is zero; the error term follows a normal distribution; the independent variables are uncorrelated with the error term; for any two observations, the errors are uncorrelated and the variance of the error term is constant.

Therefore, we first tested the estimated coefficients for each economic growth model by applying the statistical t-test. According to Wadhwa and Marappa-Ganeshan (2023), this test is a ratio that quantifies how significant the difference is between the means of two groups while taking their variance or distribution into account, and the specific hypotheses are:  $H_1 \rightarrow b_t = 0$  and  $H_1 \rightarrow b_t \neq 0$ .

In addition, the reliability of the economic growth models was checked using the F-test and the value of the adjusted coefficient of determination. We also used the F-test to test statistical significance at 5% level across the eight growth models in the case of Azerbaijan. The F-test is used in regression analysis to test the hypothesis that all model parameters are equal to zero. It is used in statistical analysis to compare statistical models that have been fitted to the same underlying factors and data set to determine which model is the best fit. The *F*-test was developed by Ronald A. Fisher (hence *F*-test) and is a measure of the ratio of variances. According to the literature (Kissell & Poserina, 2017), a general rule of thumb that is often used in regression analysis is that if  $F > 2.5$  then we can reject the null hypothesis. We would conclude that there is a least one parameter value that is not zero.

According to the Sapra (2014), Colin Cameron and Windmeijer (1997), Cheng et al. (2014), the adjusted form of the R-Squared (Adj.  $R^2$ ) has been considered in the predictive modelling as one of the most widely used reliable statistical tool for testing the goodness of fit of a model or for comparing the performance of different models. In fact, the adj.  $R^2$  is considered to be a basic and an essential tool for making a final decision about the relationship between the dependent variable and a set of explanatory variables.

In addition, the White test (1980), the Breusch-Pagan-Godfrey test (1979) and the Jarque-Bera test (1980) were used to test the assumptions of homoscedasticity of errors and normal distribution of errors for the proposed models of our analysis. The White and Breusch – Pagan – Godfrey tests are the main statistical tests that determine whether the variance of the errors in a regression model is constant: that is, for homoscedasticity under the following hypotheses:  $H_0 \rightarrow \varepsilon_t = 0$  and  $H_1 \rightarrow \varepsilon_t \neq 0$ , and if the p-value is greater than the 5% level of statistical significance, the errors are homoscedastic. The Jarque-Bera test is a reference test for the normality of errors based on the following assumptions:  $H_0 \rightarrow$  errors are normally distributed and  $H_1 \rightarrow$  errors are not normally distributed. Also, the errors are normally distributed if the p-value is greater than the 5% level of statistical significance.

A final methodological step was to carry out an analysis to predict the economic growth in Azerbaijan over the mentioned period. The following statistical indicators were used for this purpose: the root mean square error-RMSE, the mean absolute error-MAE, and the mean absolute percentage error-MAPE (Amstrong, 2001; Armstrong, 1984; Armstrong, 1988). RMSE is a measure of absolute error between the observed and simulated values. This statistical index varies from 0 to  $+\infty$ , and the smaller values have the better simulation and forecasting results. The

RMSE statistic provides information about the short-term performance of a model by allowing a term-by-term comparison of the actual difference between the estimated and the measured value and the smaller the value, the better the model's performance.

A further indicator for the assessment of the forecast was the mean absolute error (MAE) which is defined as the average variance between the significant values in the dataset and the projected values in the same dataset. Also, we used the mean absolute percentage error (MAPE) to evaluate the accuracy of the forecasting analysis. MAPE represents the average of the absolute percentage errors of each entry in a dataset to calculate how accurate the forecasted values were in comparison with the actual values. The formulas for these indicators are shown below.

$$RMSE = \sqrt{\sum_{i=1}^N \frac{(\hat{y}_i - y_i)^2}{n}} \quad (1)$$

$$MAE = \frac{1}{n} \sum_{i=1}^n (|y_i - \hat{y}_i|) \quad (2)$$

$$MAPE = \frac{1}{n} \sum_{i=1}^n \left( \left| \frac{y_i - \hat{y}_i}{y_i} \right| \right) \quad (3)$$

Where  $\hat{y}_i$  is predicted value of GDP;  $y_i$  is the observed values of GDP; and  $n$  is the number of observations.

The methodological steps followed are shown in Figure 2.

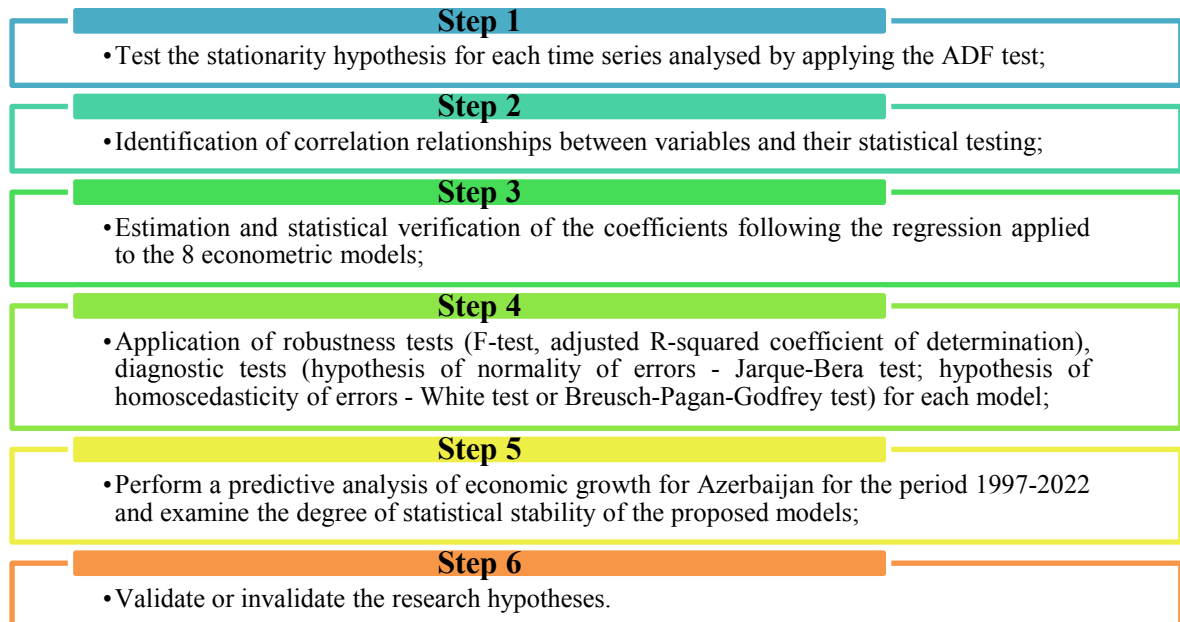


**Figure 2. The methodological steps according to the multivariate analysis**

Source: Authors' work.

As a result of the econometric analysis conducted, the research hypotheses could be statistically validated or invalidated, suggesting a number of implications and empirical evidence on the economic growth rate in the country of Azerbaijan. Our entire methodological process was carried out using EViews 12 Student Version data analysis software.

The econometric analysis conducted in this study focuses on the main factors that influence the economic growth in Azerbaijan. The methodological process was based on the development of several economic models through the application of multivariate linear regression

in order to observe the successive impact of each independent variable. Although the approach is a quantitative one, we face the emergence of various methodological limitations and challenges.

A first limitation derives from the fact that we perform the economic growth models only in a single country (in our case, Azerbaijan) and this does not allow us to assess if the proposed models are appropriate for other oil and gas producing countries. In future studies, we will test the robustness of the economic growth models in a comparative manner, using a panel approach including countries with a similar energy profile as Azerbaijan.

Another limitation arises from the availability of the data used. Most of the time, model construction and the selection of dependent and independent variables are strictly influenced by the data available. In this paper, we use annual frequency data in the time interval 1997-2022. Despite this drawback, the models could be successfully applied and the results empirically demonstrated the dependency relationships between energy resources and economic growth in Azerbaijan. However, a possible extension of this analysis is relevant for future studies, especially as energy resources play an extremely important role globally. We also do not deny that the energy sector in Azerbaijan plays a significant role in terms of economic growth and welfare, but exposure to global energy price volatility means that the economic situation and conditions of this relatively small country are likely to change in the near future.

## Results and discussions

The main results of the econometric analysis of economic growth in Azerbaijan for the period 1997-2022 are presented and discussed in this section. In this regard, this section is divided into 2 parts. The first part, where the results specific to each economic growth model, the accuracy and diagnosis of these models, together with the constitution and evaluation of the predictive analysis on the level of economic growth in Azerbaijan are studied. In the second part are studied and statistically tested the research hypotheses and the implications on the level of economic growth and economic development in this Caspian country.

### *Specific results of economic growth modelling*

In order to apply economic growth models, a first step is to study and present the correlations between the variables used.

**Table 4. Correlations between variables**

|                           | GDP         | Oil reserves | Natural gas reserves | Net trade   | Current account balance | Inflation   | Interest rate | Unempl.     | CO <sub>2</sub> Emissions |
|---------------------------|-------------|--------------|----------------------|-------------|-------------------------|-------------|---------------|-------------|---------------------------|
| GDP                       | <b>1,00</b> |              |                      |             |                         |             |               |             |                           |
| Oil reserves              | 0,71*       | <b>1,00</b>  |                      |             |                         |             |               |             |                           |
| Natural gas reserves      | 0,52*       | 0,32         | <b>1,00</b>          |             |                         |             |               |             |                           |
| Net trade                 | 0,69*       | 0,51*        | 0,11                 | <b>1,00</b> |                         |             |               |             |                           |
| Current account balance   | 0,60*       | 0,40**       | 0,14                 | 0,97*       | <b>1,00</b>             |             |               |             |                           |
| Inflation                 | 0,10        | 0,14         | 0,18                 | 0,36***     | 0,43**                  | <b>1,00</b> |               |             |                           |
| Interest rate             | -0,28       | -0,51*       | -0,50*               | 0,05        | 0,09                    | -0,26       | <b>1,00</b>   |             |                           |
| Unempl.                   | -0,92*      | -0,79*       | -0,32***             | -0,69*      | -0,57*                  | -0,13       | 0,27          | <b>1,00</b> |                           |
| CO <sub>2</sub> Emissions | 0,68*       | 0,58*        | 0,64*                | 0,34***     | 0,29                    | 0,22        | -0,52*        | -0,65*      | <b>1,00</b>               |

Note: \* indicates statistical significance at 1% level; \*\* indicate statistical significance at 5% level; \*\*\* indicate statistical significance at 10% level. "Unempl." represents the abbreviation for unemployment.

Source: Authors' work using EViews 12.

According to the results presented in Table 4, direct, positive and high-intensity correlations have been suggested between GDP - oil reserves; GDP - natural gas reserves; GDP - net trade; GDP - current account balance, which show that the economic activity in Azerbaijan is strongly influenced by the capacity of discovery, extraction and trade of domestic energy resources, which is confirmed by the increase of oil and natural gas production capacities in different fields and extraction areas of the country (Abutalibov and Guliyev, 2013; Ahmadov, 2021; Mukhtarov et al., 2020b). At the same time, the quality of the country as an energy producer and exporter is demonstrated by the positive evolution of net exports since 2010 and until now, which leads us to believe that the level of economic growth is supported by the efforts and actions to promote, initiate and systematically develop the access, transport and export routes of energy resources to European markets or those in the Asian region (Bilgin, 2011; Musayev and Aliyev, 2017; Ruble, 2017).

Positive and high intensity correlations are observed between the current account balance - oil reserves; GDP - CO<sub>2</sub> emissions; inflation - current account balance; these variables have the power to influence and cause the level of economic growth during the period analysed. In this context, it is interesting to note that Azerbaijan is taking an increasingly strong position on reducing its consumption of greenhouse/carbon dioxide emissions, having implemented national programmes and plans (Dong et al., 2021; Bocse, 2018; Bilgin, 2011) to move towards the increased use of renewable energy resources, promoting a clean and clean environment.

In addition, there is a very high indirect correlation between GDP and unemployment (-0.92), and its counter-cyclical nature and negative impact on economic growth will be examined following the econometric analysis carried out. Also, these correlation relationships between the explanatory variables and the dependent variable (the level of GDP), on the one hand, strongly confirm that there are indeed linking relationships that propagate differently on economic activity for Azerbaijan, leading us to build economic growth models and use the univariate and multivariate linear regression method.

**Table 5. Results of unit root test**

| Variables                       | At level | At first difference | At second difference | Validation  |
|---------------------------------|----------|---------------------|----------------------|-------------|
| <i>GDP</i>                      | -1,85    | -1,70               | -4,28*               | <b>I(2)</b> |
| <i>Natural gas reserves</i>     | -4.62*   |                     |                      | <b>I(0)</b> |
| <i>Net trade</i>                | -1,36    | -4,00*              |                      | <b>I(1)</b> |
| <i>Current account balance</i>  | -2,60    | -5,89*              |                      | <b>I(1)</b> |
| <i>Inflation</i>                | -3,24**  |                     |                      | <b>I(0)</b> |
| <i>Interest rate</i>            | -1,97    | -2,63***            |                      | <b>I(1)</b> |
| <i>Unemployment</i>             | -1,06    | -4,81*              |                      | <b>I(1)</b> |
| <i>CO<sub>2</sub> Emissions</i> | -0,80    | -8,92*              |                      | <b>I(1)</b> |

Note: \* indicates statistical significance at 1 % level; \*\* indicate statistical significance at 5% level; \*\*\* indicate statistical significance at 10% level. Each test includes in test equation the intercept term.

Source: Authors' work using EViews 12.

Moving forward, before applying regression for each of the eight proposed econometric models, a key step is to verify the stationarity assumption for the time series. In our case, the stationarity hypothesis was investigated by applying the Augmented Dickey-Fuller test which is used to determine the presence or absence of a unit root in a time series, with the following

hypotheses: the null hypothesis ( $H_0$ ) of the ADF test is that the time series contains a unit root and is non-stationary, while the alternative hypothesis ( $H_1$ ) is that the time series is stationary.

We found that most variables are stationary after first difference (I1), with the p-values of the tests indicating an extremely high confidence level of at least 1%.

In addition, GDP was found to be stationary after applying the second difference, while oil reserves, natural gas reserves and inflation are stationary/do not show a unit root test and are consistent at the level (in raw I0 form). As a result, the ADF test has been successfully applied, the variables are stationary, and the implementation of the econometric analysis of economic growth patterns in the period 1997-2022 for Azerbaijan can be successfully achieved. The results of the ADF test are presented in Table 5 above.

The econometric analysis involved the construction of eight econometric models to explain how the level of GDP is influenced by the reserves of energy resources (oil and natural gas), net exports, the current balance of payments situation, the inflation rate, the lending rate, the unemployment rate and the amount of carbon dioxide emissions for Azerbaijan in the period 1997-2022. In this direction, it was first possible to estimate the coefficients for each economic growth model using regression analysis, and the results are presented in the Table 6 below.

**Table 6. Results of estimated coefficients from the multivariate analysis**

|                | Intercept | Oil reserves | Natural gas reserves | Net trade | Current account balance | Inflation | Interest rate | Unempl.  | CO <sub>2</sub> Emissions |
|----------------|-----------|--------------|----------------------|-----------|-------------------------|-----------|---------------|----------|---------------------------|
| <i>Model 1</i> | 10,5098*  | 0,7196*      |                      |           |                         |           |               |          |                           |
| <i>Model 2</i> | 10,5004*  | 0,7196*      | 0,00036              |           |                         |           |               |          |                           |
| <i>Model 3</i> | 10,9592*  | 0,4230*      | 0,0273               | 0,2189*   |                         |           |               |          |                           |
| <i>Model 4</i> | 11,0136*  | 0,4543*      | 0,0212               | 0,2452*   | -0,0512                 |           |               |          |                           |
| <i>Model 5</i> | 10,4263*  | 0,4662*      | 0,0345               | 0,2462*   | -0,0501                 | -0,0349   |               |          |                           |
| <i>Model 6</i> | 15,8887*  | 0,3457*      | 0,0252               | 0,2775*   | -0,0492                 | -0,0323   | -1,2015***    |          |                           |
| <i>Model 7</i> | 22,1061*  | 0,1985**     | 0,0227               | 0,1447**  | -0,0491                 | -0,0018   | -0,5654       | -1,1212* |                           |
| <i>Model 8</i> | 17,7325   | 0,1983***    | 0,0204               | 0,1348**  | -0,0467                 | 0,00028   | -0,4172       | -1,1224* | 0,2413                    |

Note: \* indicates statistical significance at 1% level; \*\* indicate statistical significance at 5% level; \*\*\* indicate statistical significance at 10% level. "Unempl." represents the abbreviation for unemployment.

Source: Authors' work using EViews 12.

Thus, in the case of these econometric models, oil reserves have a direct and positive impact on economic growth; a 1% increase in this variable increases GDP by around 0.72%, 0.46% and 0.20% respectively over the period considered. It should also be noted that oil reserves are statistically significant at the 1% (for models 1-6), 5% (for model 7) and 10% (for model 8) significance levels. When the variable describing the dynamics of net exports is included, a positive and direct impact on economic growth is still suggested, i.e. a 1% change increases GDP by about 0.22% in the case of model 3 and 0.25% in the case of models 4 and 5.

It is also interesting to note that, in the last two models (model 7 and model 8), the impact of net exports is reduced, as GDP increases by around 0.135% in each case, although it is still statistically significant. Also, the negative and indirect effect of the lending rate on the economic growth rate is felt and is statistically significant at the 10% level of significance, contributing to a decrease in GDP of about 1.21%, which is also confirmed in the studies carried out by Akbulaev and Huseynova (2019).

At the same time, the results obtained from model 7 and model 8 draw our attention to the statistically significant negative impact of unemployment; for every 1% increase in the unemployment rate, GDP falls around 1.12%, which runs counter to economic growth and, on the contrary, leads to instability and destabilisation of economic activity. Although the analysis shows that the estimated coefficients for inflation and the current account are not statistically significant at the thresholds of relevance. However, it has been suggested that these explanatory variables have a negative influence on the level of economic growth, as GDP shows a downward trend each time. The results also reveal that natural gas reserves have a direct impact on GDP, but the estimated coefficients remain statistically insignificant throughout the analysis.

In the same direction as the studies conducted by Chontanawat et al. (2008); Ciarreta and Nasirov (2012); Dong et al. (2021); Mukhtarov et al. (2022), in the case of energy-rich countries, the marginal and low effect of carbon dioxide emissions on economic growth has been highlighted, but we note that Azerbaijan maintains its firm position and clear trend of taxing pollution and implementing policies focused on the use of renewable resources, thus promoting a green economy. In addition, the analysis allowed an evaluation of the degree of accuracy and diagnosis for the eight proposed models of economic growth and the results are presented in Table 7.

**Table 7. Results of robustness and diagnostic tests**

| Econometric model | Adj. R <sup>2</sup> | F-statistic | Prob. F-statistic | Normality test      | Homoskedasticity test |
|-------------------|---------------------|-------------|-------------------|---------------------|-----------------------|
| <i>Model 1</i>    | 0,6091              | 39,9704     | 0,0000            | 9,9007<br>(0,00705) | 1,7529<br>(0,1855)    |
| <i>Model 2</i>    | 0,5922              | 19,1525     | 0,0000            | 9,9098<br>(0,0070)  | 3,8285<br>(0,4297)    |
| <i>Model 3</i>    | 0,8504              | 48,3794     | 0,0000            | 0,80001<br>(0,6702) | 8,5756<br>(0,3793)    |
| <i>Model 4</i>    | 0,8544              | 37,6901     | 0,0000            | 3,8460<br>(0,1461)  | 17,6415<br>(0,1716)   |
| <i>Model 5</i>    | 0,8517              | 29,7231     | 0,0000            | 3,5294<br>(0,1712)  | 24,9149<br>(0,1634)   |
| <i>Model 6</i>    | 0,8633              | 27,3196     | 0,0000            | 5,1714<br>(0,0753)  | 10,3007<br>(0,1125)   |
| <i>Model 7</i>    | 0,9071              | 35,90       | 0,0000            | 2,0495<br>(0,3588)  | 11,5702<br>(0,1156)   |
| <i>Model 8</i>    | 0,9022              | 29,8452     | 0,0000            | 1,6887<br>(0,4298)  | 14,3931<br>(0,0721)   |

Note: In the brackets are the p-values of the diagnostic tests.

Source: Authors' work using EViews 12.

From a statistical point of view, each model was found to be valid and adequate for estimating and predicting economic growth, as confirmed by the high F-test values and extremely low probability values (p-values are less than 1% in each case). Moreover, the high values of the coefficient of determination in adjusted form (adjusted R-squared) indicate that GDP is explained by more than 70% by the independent variables included in the proposed models of analysis.

In our case, it has been shown that the appropriate use of explanatory variables leads to an increase in the statistical power and confidence of the proposed econometric models, the best examples being model 6 (R-squared is 0.86) and model 7 and model 8, where the coefficient of determination values are around 0.90. In order to examine the models, tests of normality and homoscedasticity of the residual terms (error terms) were applied. The probability values of the

Jarque-Bera test and the White test indicate that the economic growth models are correctly specified, adequate, fit, do not suffer from heteroscedasticity and have a normal distribution of errors.

According to the data presented in Figure 3 and Figure 4, it can be concluded that all estimated coefficients are statistically stable and that the prediction of economic growth can be implemented with good results.

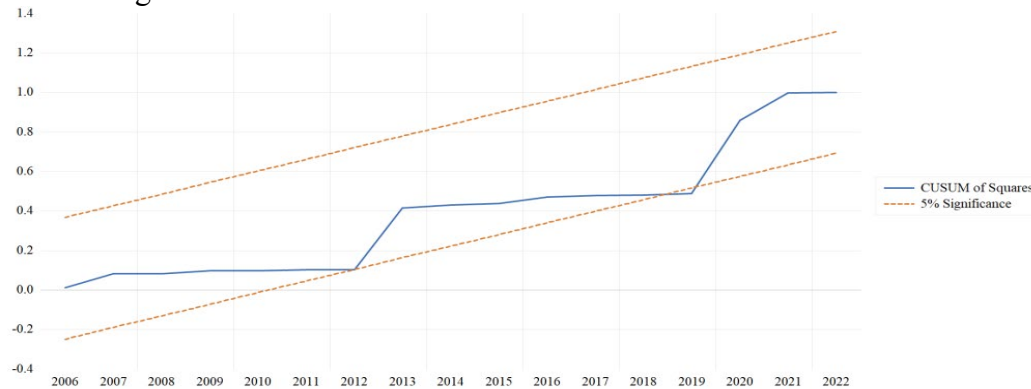


**Figure 3. Consistency test of the econometric analysis**

Source: Authors' work using EViews 12.

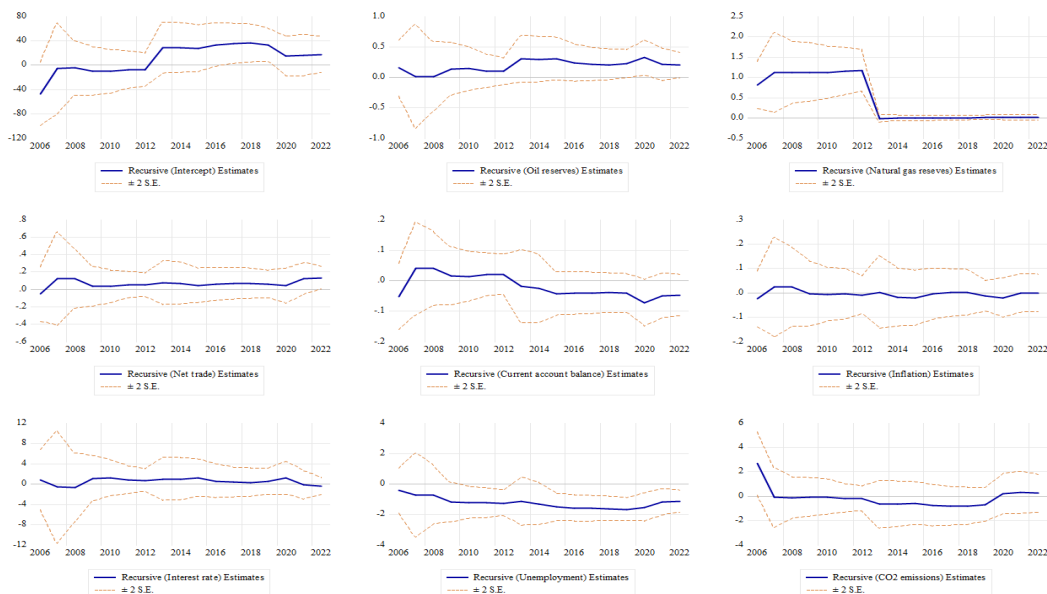


**Figure 4. Recursive coefficients estimate of the econometric analysis**

Source: Authors' work using EViews 12.

**Table 8. Forecast evaluation indicators**

| <i>Indicator</i> | <i>Value</i> |
|------------------|--------------|
| <b>RMSE</b>      | 0.165520     |
| <b>MAE</b>       | 0.1157       |
| <b>MAPE</b>      | 0.3652       |

Note: RMSE is the root mean squared error; MAE is mean absolute error, and MAPE is mean absolute percentage error.

Source: Authors' work using EViews 12.

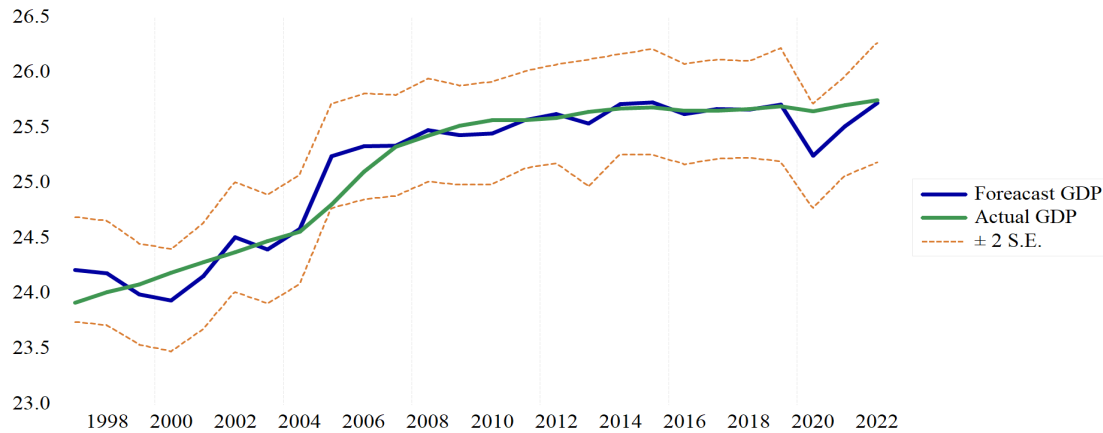


**Figure 5. Forecast analysis of GDP**

Source: Authors' work using EViews 12.

The forecasting analysis has been applied over the whole specified period (1997-2022), and its evolution and evaluation are presented in Figure 5 and Table 8. We have concluded that the prediction at the level of GDP is good, adequate and appropriate to the method used (multifactor linear regression), and the values of its accuracy indicators and evaluation (i.e. RMSE, MAE and MAPE) confirm this finding.

#### ***Growth hypothesis testing and evaluation***

The econometric analysis validated or invalidated the research hypotheses centred on economic growth for Azerbaijan in the period 1997-2022 and the results of testing these hypotheses are presented in Table 9 below.

**Table 9. Research hypothesis verification and validation**

| Research hypothesis | Definition                                                                                               | Validation                                   |
|---------------------|----------------------------------------------------------------------------------------------------------|----------------------------------------------|
| H <sub>1</sub>      | <i>Energy resources have a positive impact on the economic growth of the Azerbaijani state-level.</i>    | Partially confirmed according to models 1-8. |
| H <sub>2</sub>      | <i>Trade in goods and services and its dynamics contribute to the economic growth of Azerbaijan.</i>     | Confirmed according to models 3-8.           |
| H <sub>3</sub>      | <i>Price and financial instability have a negative impact on the economic growth rate in Azerbaijan.</i> | Partially confirmed according to model 6.    |
| H <sub>4</sub>      | <i>Economic growth and environmental pollution are negatively correlated.</i>                            | Invalidated according to model 8.            |
| H <sub>5</sub>      | <i>There is a counter-cyclical relationship between unemployment and economic growth.</i>                | Confirmed according to model 7 and model 8.  |

Source: Authors' work.

From this perspective, hypothesis 1 (H<sub>1</sub>) on the importance of energy resources for the level of economic growth was partially confirmed and validated, suggesting the positive and beneficial effects of oil reserves on economic performance. Azerbaijan is a major player in the global trade of energy resources, boosting and rationalising domestic production of these resources (especially oil), as well as discovering new oil fields (International Energy Agency, 2021; International Agency, 2023; Ahmadov, 2021; Valiyev, 2013).

The analysis shows that energy resources play an important role for Azerbaijan's economic growth. However, the domestic energy sector is highly dependent on global energy price trends and changes, which leads to uncertainty, possible external shocks and increased market risk. A good recommendation for policymakers is to reorient towards other (non-oil) sectors by adopting knowledge-based management programmes and policies. For example, a regulatory framework is needed to facilitate a smooth process of knowledge sharing and learning within and between government institutions. Effective use of digital technologies that are fit for purpose can ensure easy and timely access to knowledge resources (Mustafayev, 2016; International Energy Charter, 2020).

The second hypothesis ( $H_2$ ) is successfully validated, showing the positive impact of the trade balance on the economic growth rate of this Caspian country. In addition to this, it can be concluded that, on average, the economic growth tends to be lower in countries with a high share of resource-based exports in GDP.

In this context, it is vital for Azerbaijan to increase its export capacity by entering into partnerships and strategic agreements with energy-dependent countries (e.g. the European Union). Our recommendation is to unify and standardise the legal and regulatory conditions specific to the Southern Gas Corridor project, an ambitious project controlled by Azerbaijan. Although the main principles of the legal agreements of the projects are similar, there are still significant differences due to the different and sometimes conflicting priorities of the transit country and the project participants.

From the analysis of the hypothesis that financial and monetary instability creates problems for the economic growth trend ( $H_3$ ), we find that it is confirmed in this case. One of the main consequences is the population's propensity to save, fear and increased reluctance to lend or use borrowed money. For example, other studies (Akbulaev and Huseynova, 2019; Huseynli, 2022; Humbatova et al., 2023) have shown that by increasing the reward for saving, a rise in interest rates increases the incentive to save. On the other hand, it was observed that the lending rate was kept at a rather high level during the period analysed, which may be motivated by the inflation target and price stability. Again, it is suggested that monetary policy primarily involves changing interest rates to control inflation, and raising the bank rate is like a lever to slow down inflation. Raising it should, in theory, encourage people to save more, which will reduce demand for goods and services and lead to lower prices.

The hypothesis suggesting a link between economic growth and carbon dioxide emissions ( $H_4$ ) is statistically invalid, but it should be noted that the impact is direct and positive, and Azerbaijan needs to recognise this. An increase in the use of natural resources for various industries has led to an increase in emissions of pollutants, mainly carbon dioxide. In line with other studies that have addressed the issue of reducing consumption of greenhouse gases (Mikayilov et al. 2018; Dong et al., 2021; Azakov, 2018; Mukhtarov et al., 2022), our study follows the same direction and confirms the point that energy security, economic stability, job security, biodiversity loss, climate change and global warming all require reconciliation and solutions now more than ever. In this regard, one of the key implications is the development of policies that will lift people and countries out of poverty, while at the same time avoiding irreparable damage to the environment and the depletion of energy resources.

Another implication of the study concerns environmental policies and actions. Although Azerbaijan has one of the highest rates of energy self-sufficiency in the world and is a major producer of oil and natural gas, its focus on environmental protection and pollution reduction is now becoming an imperative. One possible recommendation is the diversification of domestic

energy sources and a strong inclination towards the use of renewable resources. According to the International Energy Agency (IEA) (2023), the Azerbaijani government is now trying to stimulate investment and accelerate implementation, which will allow diversification of domestic renewable energy consumption. In addition, the government is working on a new energy strategy that will pave the way for further policy changes. The authorities should therefore integrate energy and climate considerations into long-term urban development and transport plans, thereby limiting the increase in energy demand.

The interdependence between unemployment and economic growth was the fifth hypothesis to investigate ( $H_5$ ). Unemployment is highly dependent on economic activity; in fact, growth and unemployment can be seen as two sides of the same coin: when economic activity is high, more is produced overall, and more people are needed to produce the increased amount of goods and services. And when economic activity is low, companies reduce their workforce and unemployment rises.

According to the results obtained, it was observed that unemployment has a significant negative impact on the economic growth rate in Azerbaijan, which validates the research hypothesis and confirms the counter-cyclical nature between the two economic variables. The negative correlation between the unemployment rate and economic growth suggests that economic growth can be used as an important tool to reduce and achieve the desired employment rate. It would also mean that Azerbaijan would create favourable conditions for attracting foreign direct investment, especially in the domestic energy system, which could generate not only economic growth, but above all the stimulation and economic well-being of the population.

Although Azerbaijan had been under the influence of the Soviet Union for a long time, after gaining independence the country implemented a number of policies and measures that had a very positive impact on the diversification and development of its national economy. In this respect, the main policy options have focused on the development and rigorous and consistent improvement of the domestic energy sector. It is admirable that the Azerbaijani authorities have focused their own efforts and strengths on the oil and gas extractive industry, but the challenge remains to diversify and increase the competitiveness of other non-oil sectors of the economy.

Many of the reform programmes initiated by the Azerbaijani authorities have been aimed at ensuring macroeconomic stability, creating new jobs and improving the non-oil sectors, along with a number of aspirations and motivations for the transition to a modern, knowledge-based and sustainable economy.

In this respect, an important implication of the current economic situation in Azerbaijan, according to our analysis, is to finance and support the non-oil sectors of the economy by providing investment from the country's oil revenues. This will be beneficial in terms of reducing unemployment and increasing youth employment. In addition, the labour market in Azerbaijan, as in all countries of the former Soviet space, is extremely heterogeneous and diverse with the sectors that employ the most people are not being those that generate the highest value added per person.

For this reason, labour market policies are highly relevant in the current period to increase economic diversification and access to a modern economy. In this respect, policy makers have a responsibility to stimulate and encourage people to undertake education and training in order to increase the competitiveness of the sectors in which they work, to provide programmes for retraining and re-skilling, and to give better social protection in terms of wage increases, social security benefits, social assistance and other financial incentives.

Therefore, the econometric analysis carried out in the present study was mainly designed to test and investigate economic growth and to show how economic activity in Azerbaijan is influenced and interdependent with the extractive capacities (oil and gas reserves), balance of payments and trade dynamics, the level of CO<sub>2</sub> emissions and the existence of macroeconomic imbalances (inflation and unemployment) in the period 1997-2022.

## Conclusion

In this article, the analysis carried out allowed to study and evaluate the rate of economic growth in the state of Azerbaijan, which is considered an important and relevant global player in the production and export of energy resources: oil and gas. Its endowment with these energy resources was a basic premise for the econometric analysis, as well as the detection of a direct and positive influence on the rate of economic growth and economic development.

From a methodological point of view, eight econometric models have been developed using the following variables GDP (dependent variable), oil reserves, natural gas reserves, net exports, current balance of payments, inflation rate, lending rate, unemployment rate and carbon dioxide emissions (as independent variables). The analysis was carried out over the period 1997-2022, based on the linear regression method, presented in two forms: univariate and multivariate, using annual frequency data for each variable included in the economic growth models.

The results suggested, on the one hand, how the level of economic growth is affected and influenced differently by the explanatory variables and, on the other hand, to carry out a predictive analysis for GDP and to test the statistical validity of the above five research hypotheses such as: Energy resources have a positive impact on the economic growth of the Azerbaijani state-level ( $H_1$ ); Trade in goods and services and its dynamics contribute to the economic growth of Azerbaijan ( $H_2$ ); Price and financial instability have a negative impact on the economic growth rate in Azerbaijan ( $H_3$ ); Economic growth and environmental pollution are negatively correlated ( $H_4$ ); respectively There is a counter-cyclical relationship between unemployment and economic growth ( $H_5$ ).

In particular, it has been shown that the level of economic growth depends on oil reserves, with an increasing trend, while the interest rate on loans and unemployment causes a decrease in the level of GDP, with a negative effect on economic growth. The study was able to point out the counter-cyclical nature of unemployment on GDP, as well as the high inflation and interest rates, which inevitably lead to economic destabilisation and instability during the period under study. A key driver for securing and sustaining long-term economic growth in Azerbaijan is the growth and intensification of energy exports.

From a different perspective than the studies reviewed (Dong et al., 2021; Mukhtarov et al., 2022; Ciarreta and Nasirov, 2012), there is no statistically valid interdependent relationship between GDP and the amount of carbon dioxide emissions, but we mention the fact that Azerbaijan is consistently and persistently making real efforts to reduce its consumption of fossil fuels, with an increasing emphasis on the use of renewable and clean resources. On the other hand, the econometric analysis has shown that each model is adequate and robust, and the prediction of economic growth has proven to be efficient, good and appropriate.

The main theoretical and practical implications of our study focus on the place and the role of energy resources in enhancing and intensifying economic growth and development within the state of Azerbaijan, taking into account that energy and economic growth are linked: without access to energy, growth is impossible; and economic growth will lead to increased energy

consumption. Oil and gas are likely to remain important sources of energy for the foreseeable future. However, companies are increasingly diversifying their portfolios to include renewable energy projects and reduce their carbon footprint. Azerbaijan should increase the volume of exports of energy resources (especially natural gas and oil) in order to achieve the desired level of economic growth. This should be desirable, especially given the current tendency and inclination of this Caspian country to diversify its exports to EU member states, as well as its firm commitment to support the development of new transport routes (i.e. the Southern Gas Corridor project).

The current global economic instability, with rising inflation and unemployment, is a wake-up call to adopt new mechanisms, measures, policies and instruments to reduce their impact on economic growth. Therefore, one possible recommendation for Azerbaijan is to attract new investment projects, which should lead to a decrease in unemployment in the coming period. Another is to increase domestic production of energy resources and make it more efficient. In this context, the employment rate, increasing labour productivity in the domestic extractive and energy producing sectors, and the use of new technologies are relevant factors for Azerbaijan to achieve economic growth in the medium and long term.

The main limitations of the study are the availability of data for some explanatory variables, which conditioned and shortened the period analysed, as well as those resulting from the statistical and econometric methods of analysis. Therefore, in future studies we intend to apply and implement other methods of analysis and evaluation of the level of economic growth in the other Caspian states (i.e. autoregressive and stochastic methods: modified OLS regression, VAR and VEC models, co-integration methods, Granger causality analysis). The results obtained also lead to the development of new models for predicting and studying the economic development and economic welfare of other energy producing and exporting countries, by integrating the following variables: global energy prices, energy consumption, oil rents, foreign direct investment, employment in the energy sectors of these countries, analysed and evaluated in a comparative or a panel approach.

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